The Journal of HEREDITY

STARVED CHROMOSOMES
(SEE PAGE 115)

A Seven Generation Photo-Pedigree

Growth Hormones As Chromosome-Doublers

VOLUME 32 APRIL, 1941 NUMBER 4

The American Genetic Association

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The

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Debtors to Science

★

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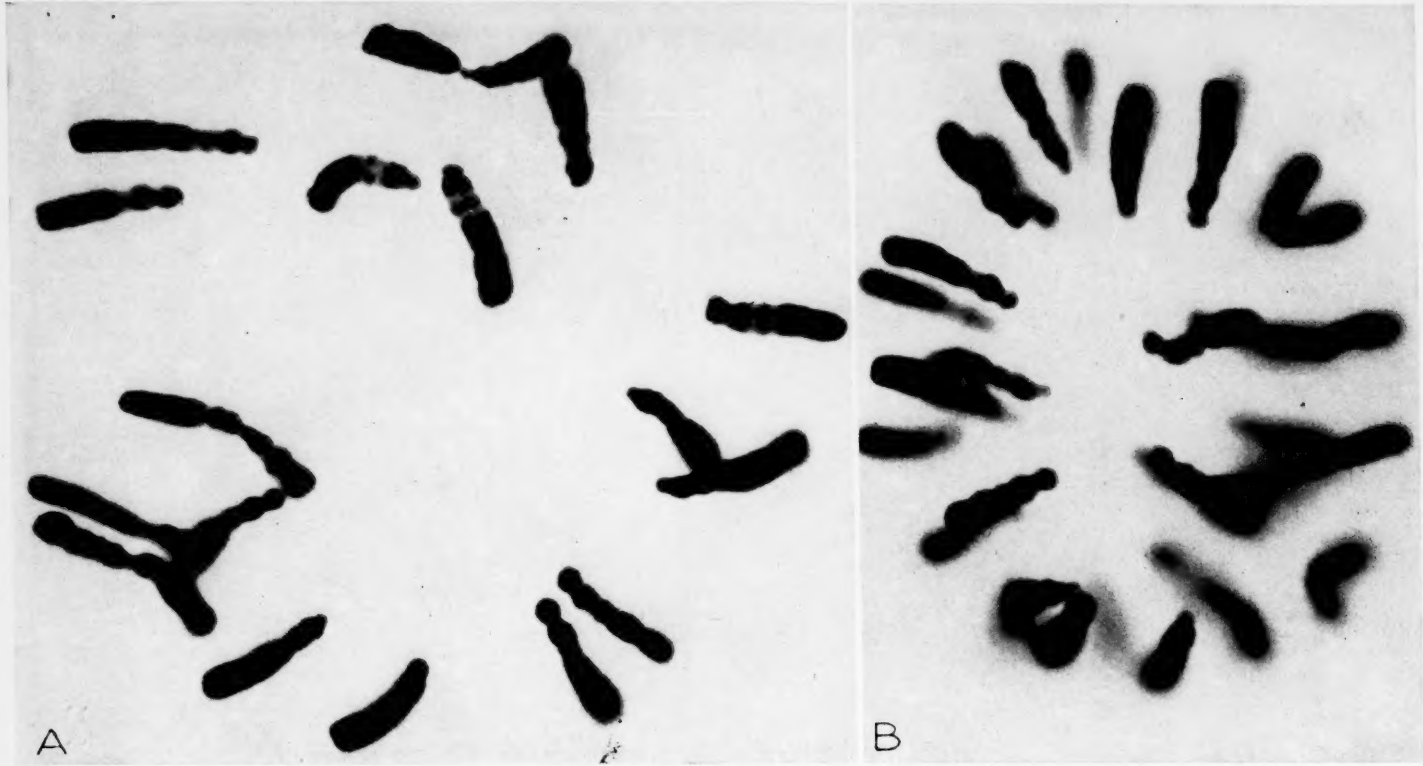

CHROMOSOMES STARVED OF NUCLEIC ACID BY COLD TREATMENT

Frontispiece

Pollen grains of *Fritillaria pudica 3x* (from Col. Grey) after more than three weeks cold treatment. The genetically inactive heterochromatin is represented by the light areas; the dark areas represent the euchromatin. The pattern is developed as shown here by the low temperature because the active euchromatin seizes the available nucleic acid at the expense of the inert regions. *A*—metaphase, *B*—anaphase. × 2300.

THE DETECTION OF INERT GENES

C. D. Darlington and L. La Cour
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Parts of certain chromosomes have long been described as inert. The *B* chromosomes in maize have been looked upon as wholly inert, the *Y* chromosomes in *Drosophila* as largely so. The criterion of this inertness is twofold: first, our inability to correlate any effect on the forms or functions of animals and plants with the presence or absence of the inert parts; secondly the absence of any spontaneous or induced mutations in these parts detectable by similar physiological effects. Inert chromosomes and parts of chromosomes can, and frequently do, undergo structural changes, but these have no direct effect on heredity.

The inert parts of chromosomes have been described as consisting of *heterochromatin* on account of their staining in the resting stage. Unlike the greater body of *euchromatin* they are charged with nucleic acid at this stage.[7] They are allocyclic in their nucleic acid relations. Later we shall see that there is a distinction of importance between the substance, *heterochromatin*, and the behavior, *allocycly*.

Allocycly is shown in the root-tip nuclei of *Fritillaria pudica*, a Californian species existing in diploid and triploid forms.[3] Preparations smeared and stained by the Feulgen reaction show darkly stained parts of chromosomes distinguished in the resting nuclei from the less heavily charged euchromatic or active segments and from the completely unstained nucleoli.

This distinction is first clear at telophase. It remains throughout the resting stage, during which heterochromatic segments may fuse to give branched structures (Figure 1). In consequence of this fusion the number of condensed bodies appears to be variable. Fusion is greatest in the smallest nuclei. For example, although all sizes of nuclei would presumably fall into the class described by Manton[8] as "reticulate," in Figure 2 we see 21 bodies in a condensed triploid root-tip nucleus, no more than in a reduced pollen-grain and fewer than in the embryo-sac mother-cell of the same plant, both of which have much larger nuclei.

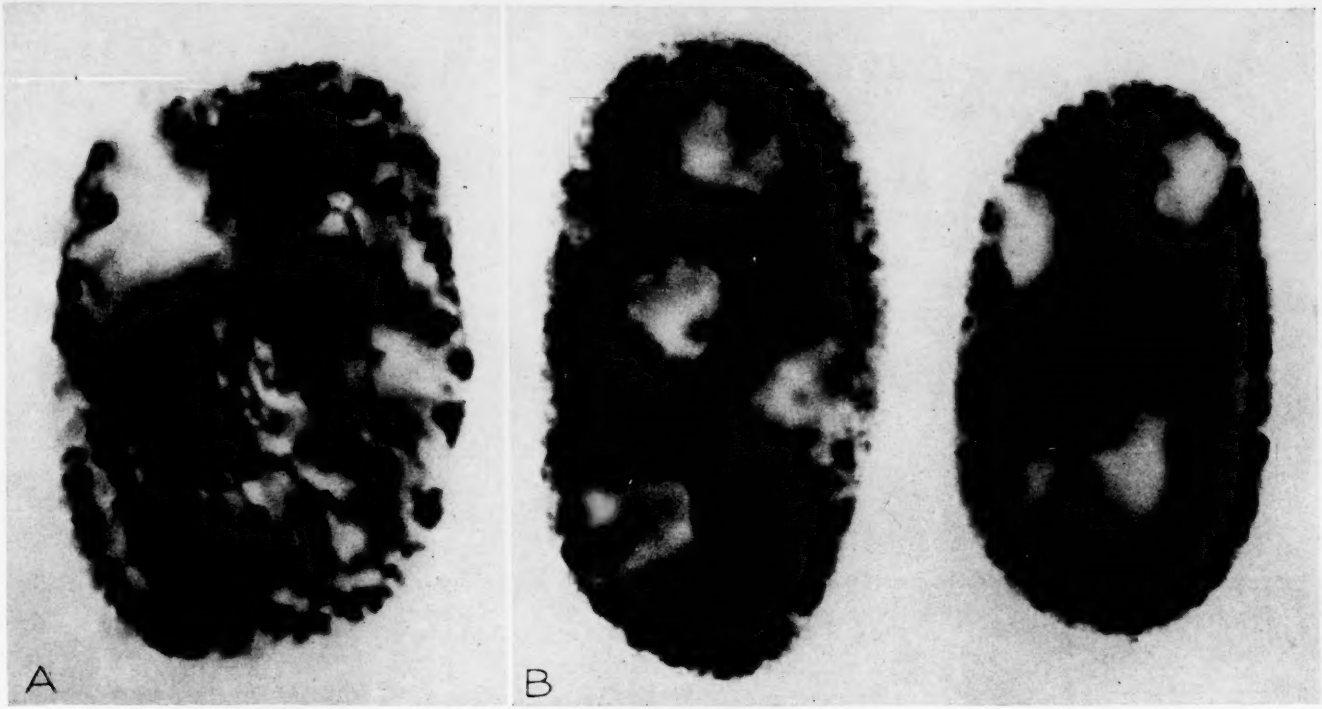
Fusion reaches its limit at the pachytene stage, when the chromosomes are paired. Evidently the corresponding heterochromatic bodies are then brought together and no more than eight are found. They are spherical and might well be mistaken for the nucleoli, which have likewise fused to form a single sphere. This is a large body, pale and unstained in our photograph owing to its negative Feulgen reaction (Figure 3). There are, we may say, for a brief interval two kinds of nucleoli together in the nucleus.

In *Paris* and *Trillium* we have shown that when the nuclei enter mitosis below 3°C they are starved of nucleic acid. Its production or distribution is hindered at a low temperature. The heterochromatin then goes short of nucleic acid and fails to stain at metaphase.[5] The same condition applies to *Fritillaria pudica*. Mitosis continues freely at freezing point, but at metaphase, whether in root tips or pollen grains, the heterochromatin segments — some 80 in number in the triploid, 35 in the diploid — appear as thinner segments faintly stained, whether with Feulgen, aceto-carmine or gentian violet. The whole of the limited supply of nucleic acid is seized by the active parts of the chromosomes.

The chromosomes of *Fritillaria pudica* are shorter and proportionately narrower than those of *Trillium* and *Paris*. The range of length is from 18μ for the *M* chromosomes to 7μ for the shortest *S*. A single still shorter chromosome is found in one of the triploids (*f* in Figure 7). It is perhaps owing to the narrowness of the chromatids that the contrast between heterochromatin and euchromatin is less emphatic than in *Paris* and hence not clear for some of the less stretched segments in the photograph (cf. Figure 7 and Frontispiece).

The heterochromatic segments being

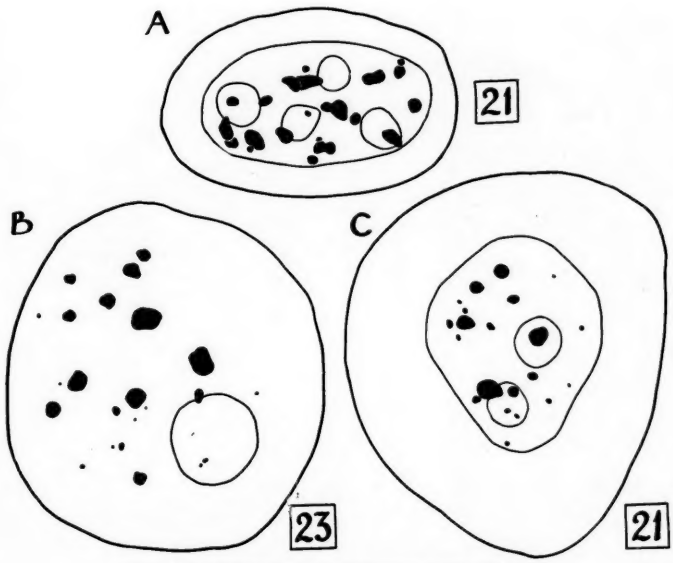
...resented by the light areas; the dark areas represent the euchromatin. The pattern is developed as shown here by the low temperature because the active euchromatin seizes the available nucleic acid at the expense of the inert regions. *A*—metaphase, *B*—anaphase. × 2300.



NUCLEI OF FRITILLARIA

Figure 1

Photographs of three root-tip nuclei in *Fritillaria pudica* 3*x* (from Messrs. Barr). *A*—Telophase with relic spirals, unstained nucleoli, and deeply stained heterochromatin segments. *B*—Adjoining but non-sister resting nuclei with different stages of fusion. All preparations were from material grown at normal temperature and stained by the Feulgen reaction. × 2300.



DISTRIBUTION OF HETEROCHROMATIN

Figure 2

Nuclei of *F. pudica* 3*x* with heterochromatin solid and nucleoli in outline. *A*—Root-tip. *B*—Embryo-sac mother-cell in leptotene stage, single fused nucleolus. *C*—Pollen grain. The numbers of heterochromatic bodies are given beside each figure. × 1000.

constant in position are a means of recognizing particular chromosomes. Homologues however do not always agree. As in *Trillium* they show hybridity. Thus the pollen grains of the diploid show a different set of 13 chromosomes in each mitosis. There are always two wholly euchromatic chromosomes (E_1 and E_2) but the single nucleolar chromosome (N) and the median chromosome (M) vary in the positions and numbers of the heterochromatic segments (Figure 4).

We have two triploid clones of this species (from Messrs. Barr, and from Col. Grey of Hocker Edge) and they differ from one another as well as from the diploid (Figures 6 and 7). They have two types of nucleolar chromosome, and the M chromosomes vary also. They both have only a single E type of chromosome.

In all these types, however, there is a kind of uniformity, and a different uniformity from that seen elsewhere. The heterochromatic segments, unlike those in *Paris polyphylla* and in most species of *Trillium*, are crowded near the centromere. A similar proximally localized distribution has been found in the newts, *Triton vulgaris* and *T. palmatus*.[1]

The relative positions of the segments are somewhat as in *Trillium*. Particularly we have to notice the minute pieces of euchromatin intercalated in some heterochromatic segments. In some cases these are no more than dots at the limit of resolution, in others they appear as half or whole coils of the spiral thread of the chromosome (Figure 5).

We are only at the beginning of understanding the conditions of allocycly. As we pointed out in *Trillium*, nucleic acid starvation requires three days to affect the metaphase of mitosis in the roots. Even at a low temperature this period must comprise most of the resting stage.

DIFFERENTIAL STAINING OF NUCLEUS

Figure 3

Pachytene in embryo-sac mother-cell of *F. pudica* 3*x* (Barr). Fused heterochromatic bodies with the nucleolus showing unbleached osmic acid effect. Note that the use of osmic acid has not impaired the differential Feulgen reaction. × 3100.

In the pollen grains the chilling has to be much longer. We have been able to obtain the starvation effect only in pollen grains which have been kept at a low temperature for the greater part of the period between meiosis and mitosis. This was possible in *F. pudica* where the period is only two months (December and January) but not yet possible in *Trillium* where the period is twice as long. The starvation effect therefore acts long before the prophase when the chromosomes are actually taking up their nucleic acid.

Another aspect of conditioning is also open to enquiry. *F. pudica* is the only species of *Fritillaria* in which we have found evidence of heterochromatin. In twenty other species, all with 12 chromosomes instead of 13, we have found no differential staining in resting nuclei. Yet we can hardly suppose that inert genes occur in this species and in none of its closest relatives. Already there is a great deal of evidence that allocyclic behaviour of the kind described as heteropycnosis in animals is variously conditioned in different organisms and tissues. The *X*-chromosomes of Orthop-

"STARVED" CHROMOSOMES

Figure 4

Pollen grain metaphases in diploid *F. pudica*, following more than three weeks at 0°C. (Figures 1-3 were from normal temperature preparations.) *N*, nucleolar chromosome. *M*, median chromosome. Both pairs of homologues differ. E_1 and E_2, two wholly euchromatic chromosomes. × 2000.

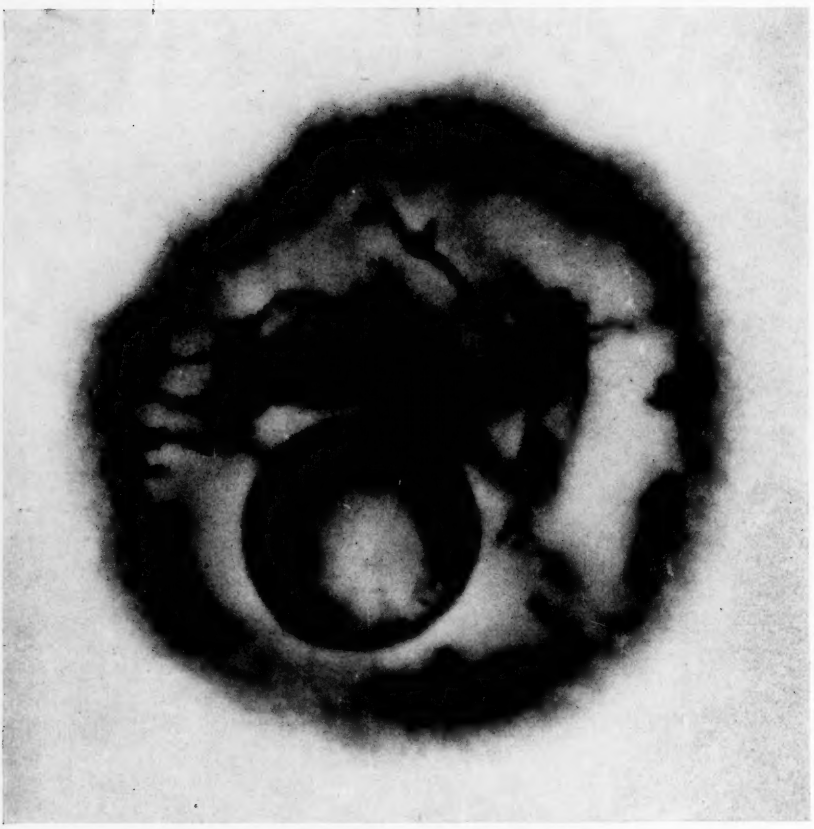
DETAILS OF NUCLEIC-ACID-STARVED CHROMOSOMES

Figure 5

Same plate as Frontispiece, spaced. n=18. *H*-chromosome with almost entirely heterochromatic short arm. × 1500. Below single chromosome (*X*) × 3300, to show intercalary half coil of euchromatin. Note the apparently greater size of these chromosomes as compared with the diploid is due to the higher pressure necessary to secure flat plates in the triploid.

tera are assumed to be heterochromatic in substance or gene content since they are allocyclic in the males. But they are not allocyclic in the females. It may be that the types of allocycly or differential staining that we have here described are likewise subject to environmental and genotypic control. For example, polyploid species of *Trillium* and *Paris* show less allocycly than diploids. We do not know that they have less heterochromatin. All species may have inert genes and only a few of them may show it. For the present we can conclude only that, whenever we see allocycly in mitosis, inert genes are present.

Why then are so many parts of chromosomes inert? Is it merely that they have been accumulated by mutation to



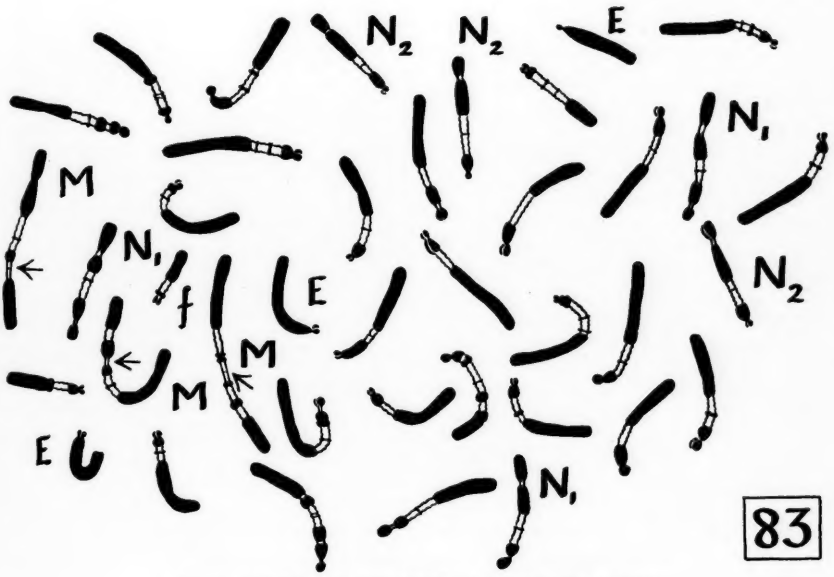
HETEROCHROMATIN AND EUCHROMATIN

Figure 6

Anaphase in root-tip of *F. pudica* 3*x* (Barr) after 15 days at 0°C. The nucleic acid has been absorbed by the regions containing heterochromatin. Three days is sufficient to show this differentiation in root-tips. × 2300.

inertness and have not been got rid of quickly enough by selection?[4] These questions will take many years to answer, but two facts speak in favor of inert genes having a use and indeed a specialized activity of their own. The first is the regularity of their positions in chromosomes. The second is the occurrence of whole extra fragment-chromosomes which are inert in equilibrium in the populations of different species.

In *Cimex lectularius* the extra *X*-chromosomes play this part. In species of *Metapodius* apparently the *Y* is concerned. And, in maize, chromosomes derived from inert parts of the ordinary set have multiplied in many varieties under cultivation and have come to be a necessary part of their genetic economy.[6] What this part may be is shown by salivary gland studies in x-rayed *Drosophila*. There the action of an active gene may seem to be influenced by the presence of inactive genes in its neighbourhood, owing to their effect on the accuracy of its reproduction.[2]



TWO TYPES OF NUCLEOLAR CHROMOSOMES

Figure 7

Metaphase chromosomes in root-tip smear of *F. pudica*, $3x=39$ (Barr), after eight days at 0°C. N_1 and N_2, two different types of nucleolar chromosome. *f* is a small chromosome derived by loss. Arrows mark the position of the centromeres in the three dissimilar *M* chromosomes. In two of them the cetric constriction has been stretched in smearing. The total number of heterochromatic segments is given below. × 1500.

The various devices that are now available for detecting inert genes are therefore worth using equally for the general study of natural populations and for the particular problem of a new form of chromosome activity.

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FACTS-OF-LIFE FOR THE FARMYARD

IN this little volume* John Hammond, who is known around the world for the wide range of his interests and inquiries touching animal physiology, growth and inheritance, tells briefly and with many illustrations how animals come into being and grow. The book is intended for general readers who are primarily interested in the animal itself rather than in the intricacies of physiology and genetics. But for the latter it will also be an introductory guide. The many references will be signposts enough to guide his next steps. The general animal husbandman will find it a compact summary convenient for reference, especially concerning such items in the physiology of reproduction as time of ovulation, when to breed, and artificial insemination. Necessarily in a book of this size there is little weighing of the pros and cons as to whether the chosen interpretation of the evidence is the only one possible.

The first two-thirds of the book concerns the anatomy and physiology of reproduction, the role of the endocrines, time of ovulation, artificial insemination, the processes of growth, etc., there being one general chapter and then for each kind of animal a separate chapter giving more specific details. The scope of the work may be illustrated by the section headings in the chapter on sheep, which are: "The breeding season. Fertility. Artificial insemination. Birth weight. Growth during suckling. Requirements of market. Development of body proportions. The skeleton as an index of productive ability. Growth of the fleece." All this for the sheep is within 28 pages, including references and many well chosen figures. The comments on growth and on early or late maturity emphasize the contrast between wild and improved races and the different rates at which various parts of the animal body develop.

The rest of the book deals with Mendelism and how the laws of inheritance apply to animal breeding. The presentation of Mendelism is necessarily brief and perhaps over-simplified but the general reader will surely not object to that! In this respect it is rather like Wriedt's "Heredity in Livestock." The discussions of evolution, selection, inbreeding, crossbreeding, and special problems in breeding for production in each class of animals reflect the considerable advance during the decade since Wriedt's book appeared but the general picture of these relations is still sketchy.

It is not to be expected that such a wide range of subjects could be treated with no errors at all. Americans will be a bit startled to learn that the Poland China is now a "bacon type" (page 99) although they agree that it has changed markedly in the last thirty years. Are so many genes for horse color really in one allelic series as is implied on page 142? Are there really only 18 chromosomes in the fowl (page 146)? Galton's Law is still presented in wording which implies that remote ancestors exert some influence on an individual other than through their influence on the genotypes of the immediate parents.

This book will be consulted and remembered chiefly for its concise presentation of the highlights in the field of physiology of reproduction, endocrinology, and artificial insemination, and for the comments on characteristics of meats. A stockman who wants to know what makes the animals tick, or a student who wants a mountain peak view of the territory before he begins the real grind of a gene-by-gene or hormone-by-hormone survey, may find this book an answer to prayer.

JAY L. LUSH

Iowa State College

*Farm Animals. Their Breeding, Growth and Inheritance. Pp. 199. Longman,s Green & Co. New York. 1940. $4.50.

A REVERSIBLE VARIEGATION IN PETUNIA

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IN the summer of 1936 a plant of the common garden petunia (*P. hybrida*) was found which bore on separate branches normal (self-colored) and variegated (flecked) flowers. The plant was removed to the greenhouse and kept under observation for a little more than one year. During this time it continued to produce both normal and variegated flowers. These two flower types were strikingly different in appearance as shown in Figure 8*A-B*. The normal flowers were dark bluish violet in color (Amethyst Violet, Ridgeway) whereas the variegated flowers at a distance of a few feet appeared to be white but on closer inspection were seen to show minute dark flecks upon a pale background. Rarely, a variegated flower showed a colored sector extending from the throat to the outer margin of the corolla.

As far as the writer is aware, the only variegation heretofore reported in *Petunia* is a mosaic form studied by Malinowski and Sachsowa.[3] The writer has for some years maintained cultures of a variegated strain which appears to be identical with that reported by Malinowski and Sachsowa and crosses between this latter form and the flecked type herewith reported show that they are genetically distinct.

In order to study the inheritance of *flecked*, variegated flowers of the original plant were crossed with two normal stocks, one a variety with dark violet flowers, the other a white-flowered type. Thirty-eight F_1 plants were obtained from the cross, *variegated* × *dark violet*, and ten plants from the cross, *variegated* × *white*. All F_1 plants bore self-colored flowers. Segregation in the F_2 and back-cross generations is shown in Table I.

As shown by the F_2 and back-cross data, the variegation was inherited as a simple recessive character. Some of the variegated segregates bore both variegated and normal flowers as did the original variegated parent but others showed marked variation in the character of the variegation. Three principal types were observed: *dark-flecked on pale* (Figure 9*A*), *pale-flecked on dark* (Figure 9*B*), and mixed types (Figure 9*C*). An additional mixed type occurred in which the pale and dark spots instead of being segregated on different background colors as shown in Figure 9*C*, were intermingled on a common light violet background. This type was of relatively infrequent occurrence.

Among the variegated segregates, individual plants were found which showed a high degree of constancy in the type of variegation produced. For example, plants were repeatedly observed which bore only variegated flowers of the dark-flecked on pale (Figure 9*A*) type. Moreover, such plants have been kept under observation for periods up to a year during which time several hundred flowers were observed on individual plants, every flower being of the type shown in Figure 9*A*. Segregates showing the pale-flecked on dark (Figure 9*B*) variegation were less constant since the pale sectors of more than 2-3 mm. in width almost invariably bore dark flecks. But here, too, individual plants showed a very restricted range of variegation. In contrast to the relative constancy of the variegations just described, sister plants occurred which showed in one individual all the types of variegation illustrated (Figure 9) together with self-colored

TABLE I.—Segregation for variegated (flecked) and normal (self-colored flowers in *Petunia*).

Culture number	F_2 Normal	F_2 Variegated	Expected	Standard Error
1602	43	7		
1614	39	10		
1751	46	18		
1752	41	12		
Total	169	47	162:54	6.1
		BACK-CROSS		
1627	53	43		
1637	54	42		
Total	107	85	96:96	6.9

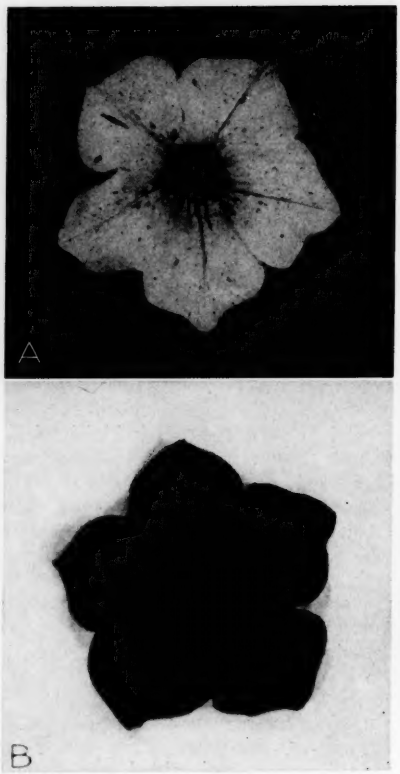
flowers. It is clear that the variegation is reversible though its expression in a single flowers or even a single plant may be in one direction only.

The present variegation, it should be noted, produces self-colored dark (normal) flowers but it has not yet produced self-colored pale. The so-called "pale" flowers and even "pale" spots, except those not more than 2-3 mm. in width, are always dark-flecked. Thus *pale* is highly unstable. The production of self-colored flowers by *variegated* indicates mutation to a relatively stable *normal*. This is in contrast to *pale-flecked on dark* which may be regarded as an unstable *normal*.

Factors Causing Variegation

The frequent occurrence in variegated cultures of plants which bore exclusively dark-flecked on pale flowers has already been noted. Why should a reversible variegation produce plants which show this one-way change? The writer is inclined to believe this is due to segregation for modifying factors which affect the time at which mutation occurs. It seems clear that in variegated flowers the small spots originate late and the larger spots earlier in ontogeny. Thus although *pale* is quite unstable, in plants which bear only dark-flecked on pale flowers, the instability is limited to a very late stage in the development of the flowers. Moreover, any factor which limits change to a late stage in flower development will tend to transform a reversible type into a one-way variegation. That variegation is affected by modifying genes is indicated by the work of Emerson[2] and especially by Rhoades'[4] study of dotted aleurone in maize.

Self-sterility of the petunia variegation has prevented the isolation of strains which would make possible a satisfactory test of the modifying gene hypothesis but evidence that modifiers were present was obtained from crosses between plants bearing only dark-flecked on pale flowers. These crosses reproduced in F_1 the whole range of variegated types, dark-flecked on pale, pale-flecked on dark, self-colored and mixed types.



ORIGINAL FLECKED TYPE

Figure 8

A—Flecked flower from original variegated plant. *B*—Normal flower from original variegated plant.

Reference has already been made to a mixed type of variegation involving both pale and dark spots on flowers of an intermediate (light violet) color. Like *pale, light violet* is quite unstable but whereas *pale* can change only to *colored, light violet* shows change in two directions. Because of this fact it was possible to compare the rates of change to *pale* and *dark* in the *light violet* type. The smaller spots, both pale and dark, were so numerous that satisfactory counts were not obtained. Accordingly, counts were made to determine the frequency of spots whose length was at

least one-half the length of the corolla lobes, i.e., the main veins of the lobes.

Because of self-sterility, the variegation has been maintained by intercrossing variegated plants derived from the cross *variegated* × *normal*. Thus it is likely that genetic differences are present in the variegated stock. It would, therefore, be unsafe to assume that the rates of change in different variegated plants are comparable. For this reason the data on each light violet plant have been kept separate. Three plants, 1803-3, 1803-12 and 1804-7 were available for data on changes in the light violet type. None of the three plants bore exclusively light violet flowers. Number 1803-3 bore *light-violet* and *self-colored*; 1803-12 *light-violet, pale-flecked on dark,* and an occasional *dark-flecked on pale*; and 1804-7 *light-violet, self-colored,* and occasional *dark-flecked on pale.*

In the three plants studied, as shown by the table, change to *pale* was respectively 13, 16 and 38 times as frequent as change to *dark* in the early development of the flowers. Thus the reverse changes differed widely in frequency.

Typically one-way variegations sometimes produce a low percentage of reverse changes. Emerson[1] found such reversals in variegated pericarp in maize. The production of a low proportion of reversals would seem to be as much the property of the gene as the more frequent changes in the other direction. Hence variegations of this type may be regarded as fundamentally reversible.

TABLE II.—Showing frequency of pale and dark spots on light violet flowers in *Petunia*.

Plant number	Number of flowers	Pale spots	Dark spots	Ratio Pale:dark
1803-3	94	140	9	16:1
1803-12	110	188	5	38:1
1804-7	191	320	24	13:1

DERIVED TYPES

Figure 9

Types of variegation from F_2 of *variegated* × *normal*. *A—Dark flecked on pale. B—Pale flecked on dark. C*—Mixed types of variegation in one flower. All figures natural size.

It is very difficult to determine beyond question the genetic nature of the somatic changes produced in a reversibly unstable character such as the present one and it may be stated frankly that no proof has been adduced that the changes are mutations. Nevertheless, the author has little doubt that these changes are genotypical. In any event they bear upon the problem of variegation. It may be noted that the characteristic form of the spots clearly indicates their origin from single cells and that such a mode of origin is to be expected of genotypic rather than of phenotypic changes.

The behavior of *flecked* indicates that one-way variegations may sometimes be derived from types showing reversible change. But due to the self-sterility of the strain it has not yet been possible to carry out the necessary selection experiments to determine whether true-breeding dark-fleckd on pale or true-breeding pale-flecked on dark types can be obtained.

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FIRST THINGS FIRST

AS Lord Horder once remarked, there would be room in the medical curriculum, were other *less important* things discarded, to make a place for a course in inheritance in disease. The students might be spared learning the times of appearance of all the ossification centers in the bones of the body, that being better typed upon a card and hung above the desk than carried in the head to the exclusion of more important matters. The same might be said of so much antomical detail which the ntudent is expected to cram into his mind, and which he never uses unless he does so at the autopsy table, at which time he can look up the standard measurements and weights of organs. He might give up learning what veratrin and curare do to frog's muscles, which he will never use in his clinical work, for the sake of learning the syndromes which he will meet in his patients. He will probably never hear of many of the hereditary disorders unless he learns of them in a course in genetics. There is not much use in hoping that students will read about inheritance in disease after they leave medical school unless they are taught the rudiments of the subject in their student days. To the physician who knows something of the laws of inheritance, and what types of disease are likely to be inherited, examples of hereditary disorders are constantly manifesting themselves; to the physician who knows nothing of this fascinating subject, they are completely lost.

The following is an example. Not long ago a friend told me of an acquaintance who had suddenly developed intense swelling of the eyelids, so that she could not see. Several physicians had seen her, treated her ineffectually, and she still remained a blind prisoner in her room. I asked if she had any relatives who had had similar experiences, thinking that she was probably a sufferer from hereditary angioneurotic edema. The victim was quite surprised when questioned whether any of her family had a similar trouble and asked how I knew. In view of the fact that this disease can be so swiftly fatal if it attacks the vocal cords, or the laryngeal mucosa, it would have been desirable for the physicians in question to have attempted first to detect any external factor which might bring on the edema, and second, if there was any therapy which would reduce the edema, to give her directions to always have it about her, and to take it at the slightest sign of the trouble. None of the physicians had recognized the true character of the edema, nor that it could affect the laryngeal mucosa as well as the eyelids.

* * * *

A knowledge of inheritance is of value when the physician is asked to give advice to a mother who has had a malformed child. She wants to know whether she is likely to have another such mishap. No matter how rare the defect, the physician can not assure the parents that such a mistake can not occur again and the subsequent children are certain to be normal. If such assurances are given, the unexpected often happens and the mother has a second defective child. It is heartbreaking for the parents who have relied upon the doctor's assurances when such an accident occurs and it is detrimental to the doctor's prestige, and not infrequently loses for him the family and their friends as patients.—MADGE T. MACKLIN, *Scientific Monthly*, Jan., 1941.

INHERITANCE OF HUMAN FACIAL FEATURES

A Pedigree Study Involving Length of Face, Prominent Ears and Chin Cleft

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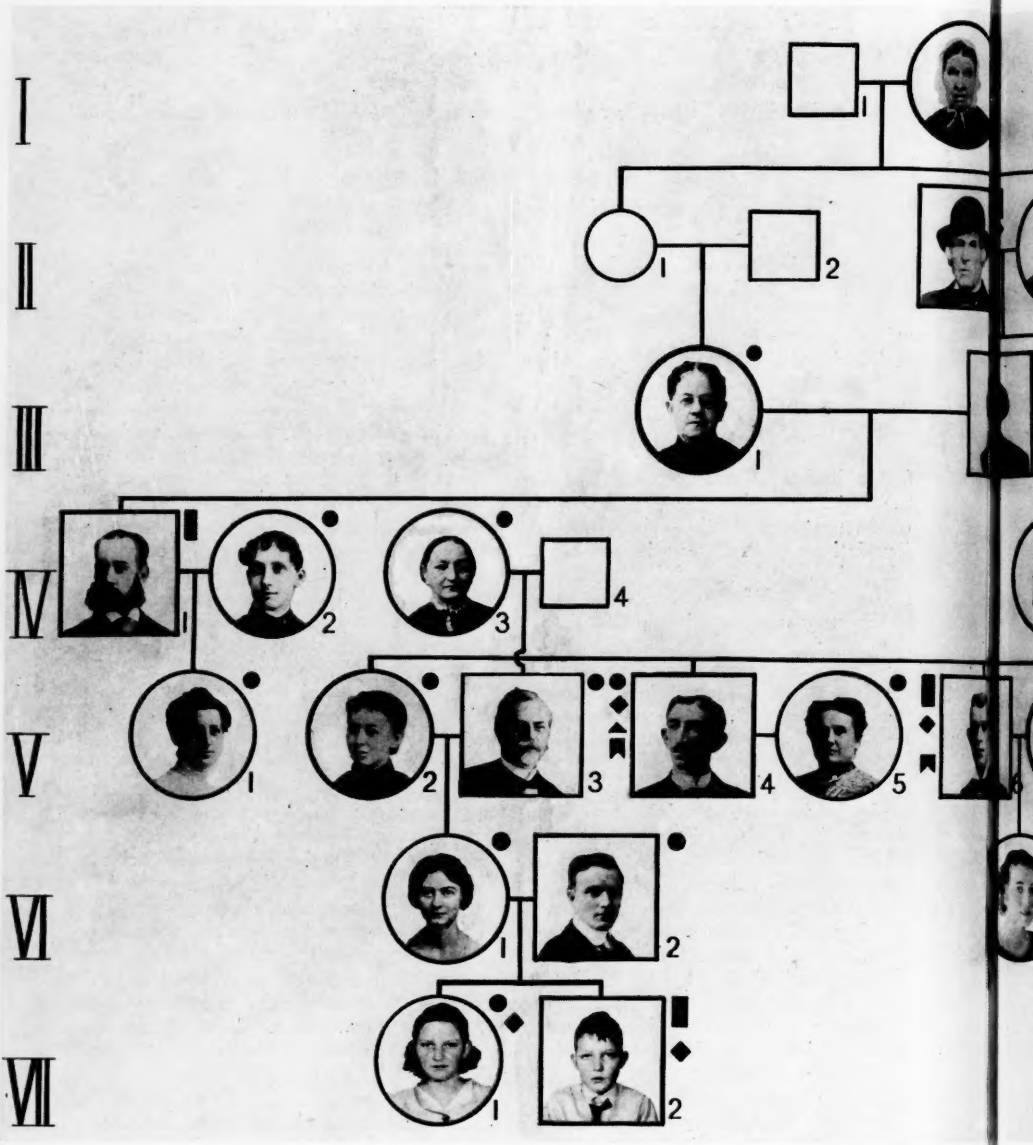
Brown University, Providence, R. I.

MODERN studies of irregularities in human facial features and attempts to correct disfiguring departures from the norm had their origin shortly after the turn of the century. It is an interesting coincidence that just at this same time Mendel's laws were rediscovered and corroborated by studies of a great many plant and animal forms including man himself. At just the same time that the groundwork of modern genetics was being laid, the foundations of the new science of "dental orthopedia" prepared the way for two textbooks[1, 2] for what today is one of the important branches of dental practice. Most variations in the teeth and jaws were then supposed to be the direct result of environmental influences and many of these influences were thought to lead to profound changes in external features.

The possibility that such variations could be in any way inherited, seems never to have greatly impressed the early students of orthodontia although inheritance of many other characters was accepted at the time as obvious fact. The striking facility with which many abnormalities could be corrected by environmental manipulation led to the concentration of all efforts in this direction. Curiously enough the inheritance of some variations such as toothlessness, teeth without enamel, abnormally large incisors or canines, or increases or reductions in the number of teeth, has been studied almost exclusively as a matter of scientific interest rather than because of any ultimate importance to the dental profession. They are variations which attract attention because of their conspicuousness and their obvious tendency to run in families. Neither the dentists nor the pure scientists paid the slightest attention to the inheritance of less-marked features of the lower face and jaws.

The fact that certain characteristics of the teeth and gums were inherited in a simple Mendelian manner, with a regularity which would make possible the prediction of the recurrence of the character in subsequent generations would seem to be a matter of vital importance to dentists. This has not been the case because these disfiguring or actually pathological defects are not the variations which attract most of the professional attention of orthodontists. Relatively minor defects are, on account of their greater frequency, the major preoccupation of the dental surgeon. If the disharmonies of the underlying osseous tissue of the jaw and the conformation of the overlying skull, which long have been most puzzling, should likewise prove to have an hereditary as well as an environmental background, an entirely new approach to the correction of such defects would be necessary. Since rational treatment of any abnormality necessitates a correct diagnosis and the determination and removal of underlying causes, the ability to distinguish developmental influences of an inherent nature, if they do actually exist, would not only be most advantageous, it would be imperative that such knowledge be applied in diagnosis and treatment.

While speculating as to the probable inheritance of such variations the attention of one of the authors (M. R. L.) was attracted to the striking contrast in facial conformation manifest in a brother and sister then under treatment. Through the interest and cooperation of their living relatives it has been possible to assemble a pictorial pedigree (Figure



A SEVEN-GENERATION PE

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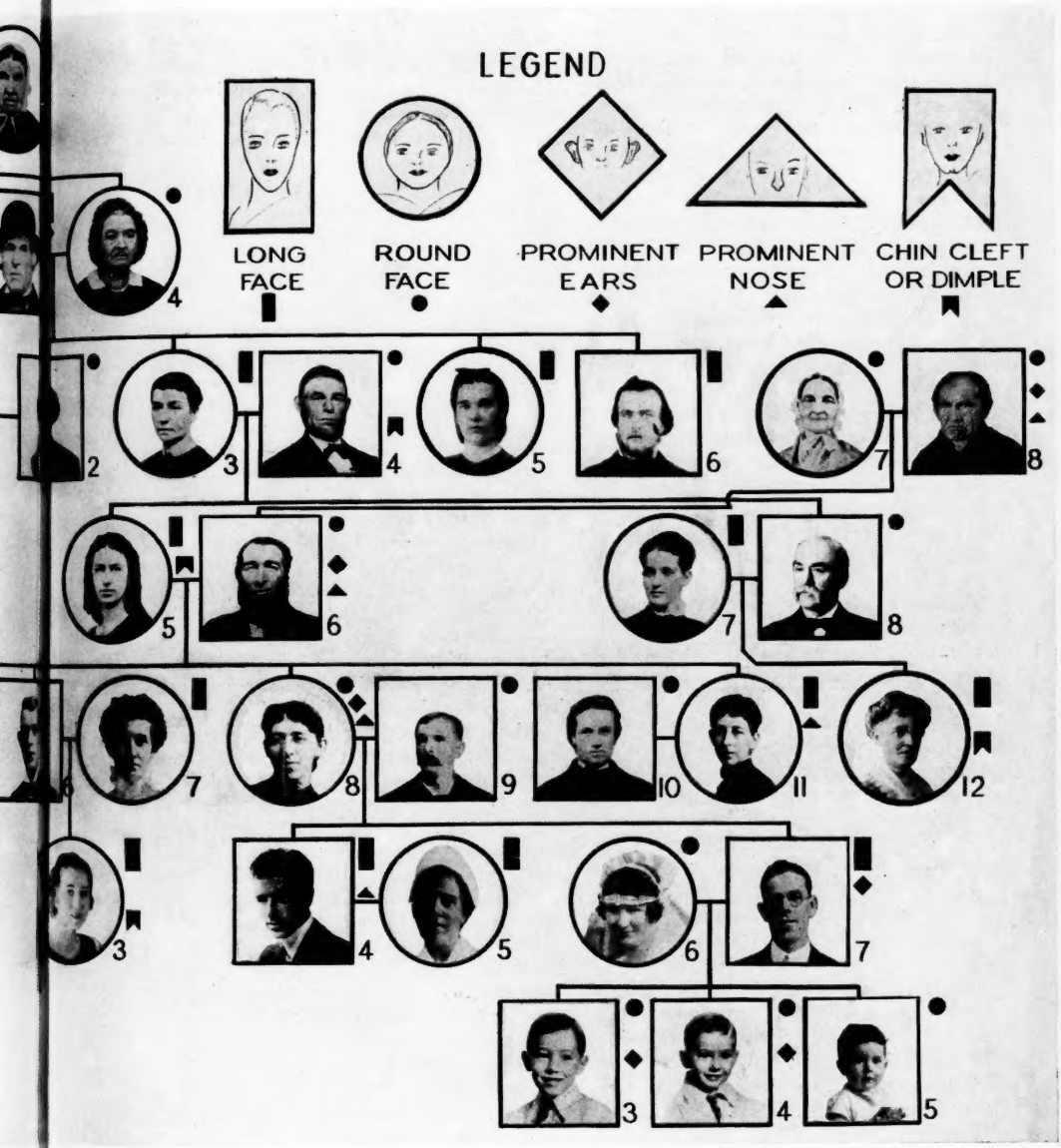
A collection of photographs of a family showing several clearly defined heritance of shape of face, cleft chin, length of nose, and position of e. Whil method of inheritance of such characters it does constitute a valuable a unique



NERATION PHOTO-PEDIGREE

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clearly defined alternative characters gives a unique opportunity to observe the in-
n of e[illegible]. While this single pedigree can hardly be taken as finally determining the
uable a[illegible]nique addition to our knowledge.

10) which enables us to trace several not uncommon facial features for seven generations to ancestors settling in Rhode Island at about the time of Roger Williams. These were, prominent ears, a prominent nose, a cleft chin and an unusually long face. The first three of these features are of more biological than professional interest, but length of face is a character which is a definite component of the previously mentioned problem of conformation. The manner in which this character not only appears to run in the family but the way in which it segregates in a more or less regular fashion is worthy of more than passing notice. If the techniques and standards of measurement which the orthodontists have developed could be applied to more cases of this type it would seem not impossible that much could be learned as to the actual manner of inheritance of such traits. The theoretical and the very considerable practical utility of such information would be of definite value. Unfortunately it has not been possible to obtain actual measurements of many of the individuals of this family but the pictorial results are presented with the hope of stimulating interest in this direction. The only individuals included in the pedigree are forty-two members of the family of whom satisfactory photographs or daguerreotypes were obtainable.

Shape of Face

Contrasting types in facial shape were first observed in the two children, sister and brother VII-1 and VII-2 (Figure 10), the former possessing a broad or round face whereas the latter has a long face. The origin of the long face character can be traced back seven generations through the great-great-grandmother IV-5, to the original maternal ancestor I-2 from which are descended thirteen long faced individuals III-2, 3, 5 and 6; IV-1, and 5; V-6, 6, 11, and 12; VI-4 and 7; and the propositus VII-2. Although the classification of these individuals is arbitrary and the characters in some of the pictures have been obscured by the manner of hairdress or other facial adornment of the times, the classification of each individual has been substantiated as being the type recognized by other members of the family.

Several interesting facts of genetic significance are evident:

1. Long face occurs rather *infrequently* and *from round-faced parents.*

2. It *skips generations* as in the case of individual IV-1 who could have obtained the trait from either his great-grandmother I-2 or his grandfather II-3 by way of his parents who were first cousins. Individual VII-2 likewise obtained it from his great-grandmother IV-5.

3. *Mating of round-faced hybrid carriers of long face* such as II-4 and IV-8 *to long-faced individuals* II-3 and IV-6 respectively *produce both long- and round-faced progeny.* They are not in equal numbers as might be expected if the trait were transmitted in a simple mendelian manner, but the number of progeny is small.

4. *Mating of known heterozygotes produces both kinds of progeny* although the numbers are too small to form a significant ratio.

5. Only one mating of *long face by long face* is at hand. Individuals V-6 and V-7 have one daughter VI-3 who is long faced. Additional matings of this type are of special interest in order to determine whether or not they breed true, as they should if long face is a simple recessive.

Each of these listed observations is a characteristic frequently found in a pedigree of a trait which segregates in a typical and simple mendelian manner. It would be folly, however, to draw the definite conclusion from these meager data that the manner of inheritance of this trait is of this simple nature, especially in view of the craniometric studies of Cameron[3] and also studies by Castle[4] of adult body size in the rabbit and by Green,[6] Castle, Gates and Reed[5] on the mouse. In the latter cases the inheritance of the character is believed to be the result of numerous hereditary influences acting in a cumulative manner. Cameron found that with respect to both facial width and height, the races of man fall

into several distinct groups but that there is no hard and fast zone of demarcation between them. Both measurements display wide ranges of variation within races which in some cases are overlapping. It is quite probable that if all of the individuals in the above pedigree could have been subjected to quantitative measurement there would be a similar overlapping of types. In fact there are several individuals which have been arbitrarily classified as round but which if accurately measured might well be classified as intermediate in facial length, and would constitute evidence of the continuous nature of this variation.

The most complete study of this sort of variation is to be found in the recently published researches of the late Doctor C. R. Stockard and his co-workers.[7] Comparison of nine different indices of the skull and jaws obtained from several long snouted and several short snouted breeds of dogs and of the same indices obtained from the F_1 and F_2 generations of crosses between them reveals a dominance of the proportions of the long snouted dogs in the F_1 and a tendency for the segregation in the F_2 to cluster around the types of the parental races. However, the variation is clearly continuous, rather than discontinuous as is to be expected from characters determined by a single genetic difference. Furthermore, extreme parental types were not obtained in most cases, which is another characteristic of variations determined by numerous hereditary factors.

In the light of such experimental data it is too much to expect that facial conformation in man will actually lend itself to a simple mendelian interpretation. Nevertheless the repeated appearance of the long face in successive generations regardless of the phenotypes of the marriage partners concerned is difficult to conceive of as resulting either from environmental forces alone or as being due to the fortuitous recombination of any great number of hereditary influences. Since no two individuals develop in absolutely the same environments, phenotypic variation is always present and this may account for the observed small departures from the strict long or round faced types. It is also quite possible that certain families, even certain racial groups are homozygous for several genes determining face shape. Thus we may get a simpler pattern of inheritance in some families than in others.

It is recognized that the pedigree method is not the most satisfactory method of complete analysis in dealing with a complex variation depending on a complete genetic constitution. Particularly is this true in man who is notoriously hybrid with respect to so many characteristics and in whom experimental control is out of the question. The results obtained by Stockard and his co-workers with variations so closely resembling the disharmonies found in man suggest a way that the problem of evaluating the hereditary influences in jaw development may be attacked. The problem is by no means hopeless if the recognized inadequacies of human material can be supplemented by experiments on laboratory animals in which it is possible to make controlled matings of genetically uniform material.

Chin Cleft or Dimple

A second character, the presence of a striking dimple or cleft in the chin, had its beginning in this family in individual III-4 where it was so well developed as to be a nuisance in shaving. It was consequently obscured in later life by the beard shown in the photograph. The fact that the character was directly transmitted to IV-5 and through her to V-4 and V-6, and to still another generation in VI-3, suggests dominance of the character. However, the cleft is also transmitted to V-12 from III-4 by way of IV-8. Neither IV-8 nor his wife (IV-7) possessed the character. Thus, the trait has skipped a generation making its inheritance as a recessive the more probable although neither interpretation here has adequate proof.

Prominent Ears and Nose

Attention should also be called to these two traits which quite obviously are running in the family. Due to the style of

hairdress the identification of the first character is in some cases doubtful and therefore interpretation of the manner of inheritance is not reliable. Similarly a prominance of nose has been recognized as a family trait although photographically it is not distinctly portrayed and therefore correct evaluation is impossible. It is, however, interesting to note that all of these latter characters are combined in individual V-4 showing how these facial features may unite to produce a very definite and distinct facial type.

Conclusion

A pictorial pedigree of seven generations and forty-two individuals manifests a segregation of the characters long versus round face, prominent nose and ears and cleft in the chin, in a manner which is in harmony with simple mendelian interpretations if it is assumed that minor variations are phenotypic in their origin. Attention is called to the significance of such variation in the practical treatment of facial conformation by the orthodontist.

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FACTS-OF-LIFE FOR THE ORCHARD

Modern Fruit Production, by Gourley and Howlett, of Ohio State University, is really an excellent new text book of horticulture. The material presented is generally well digested and up-to-date. The authors have been chiefly interested in physiological work with the apple, so that the book is most satisfactory for students (and fruit growers) in regions of the United States where apple growing is important. The breeder will find the chapters on "the plant and its parts," "factors affecting flower formation," "fruit setting" and "origin and improvement of fruits" very helpful. The chapter on fruit setting is in general excellent.

Those interested in small fruits may find the material somewhat less satisfactory than those interested in tree fruits. Thus in the chapter on the "fruit plant and its parts" the flower bud differentiation of the cranberry is not mentioned. A number of minor errors to be corrected in a later edition are noted. For students, and research workers in pomology as well, the authors have written a very fine and readable book.

Geo. M. Darrow.

*The Macmillan Company, New York. 1941.

INTRANUCLEAR POLYPLOIDY IN BEAN INDUCED BY NAPHTHALENE-ACETIC ACID*

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FOR some time a number of growth-regulating chemicals, often referred to as plant hormones, have been used in connection with physiological studies of plants. These chemicals, when applied to some plants, have produced tumorlike growths.[6] Such a growth was induced on internodes of bean plants by applying 0.25 per cent naphthalene-acetic acid in lanoline paste (Figure 11*A*). A small section of the tumorlike part of the bean stem was cut off and fixed in Wilson's modification of Bouin's fluid,† further modified by the writer, which is especially adapted to show good chromosome plates in dividing cells and stains nuclei as well. Paraffin sections were made tangentially as well as transversely. Since growth in the treated region resulted in a thickening of the stem, tangential sections often provided chromosome plates that could be observed in face view, and thus counting the chromosomes in many dividing cells was made feasible. In a few instances face views of chromosome plates were also detected in cross sections.

It has been known that in some cases simple polyploid shoots can be obtained from callus tissues, not induced by application of growth substances. Lindstrom and Koos[8] were able to isolate from the calloused material over 30 per cent diploid shoots from a haploid plant, and tetraploid shoots from the diploid. Greenleaf,[5] working with *Nicotiana*, was able to produce good callus growth, but only after applying 1 per cent indole-3-acetic-acid in lanolin to the cut surface of the stem. From the induced callus tissue a large number of shoots were produced, of which about 14 per cent were tetraploids and octoploids. Beal,[1] investigating the response of Lilium to indole-acetic acid, examined regions showing "active and fairly rapid divisions of cells," but found no evidence of polyploidy. Levan[7] has stated: "As is well known, the influence of growth substances on roots is quite different from that on shoots. Almost all concentrations, with exception of the most diluted ones, inhibit root elongation. In addition to this effect, high concentrations bring about very characteristic swellings of the root." He induced such swellings in the root tips of *Allium* by applying either solutions of naphthalene-1-acetic acid or indolyl-3-butyric acid, 1-10 p.p.m. His cytological examination of the affected roots revealed internal multiplication of chromosomes in the resting nuclei. Such an intranuclear increase of chromosomes was recently reported by Berger[2] for animal material. The same phenomenon was observed in some parts of the chemically induced tumorlike growth of the bean, which is reported in this paper.

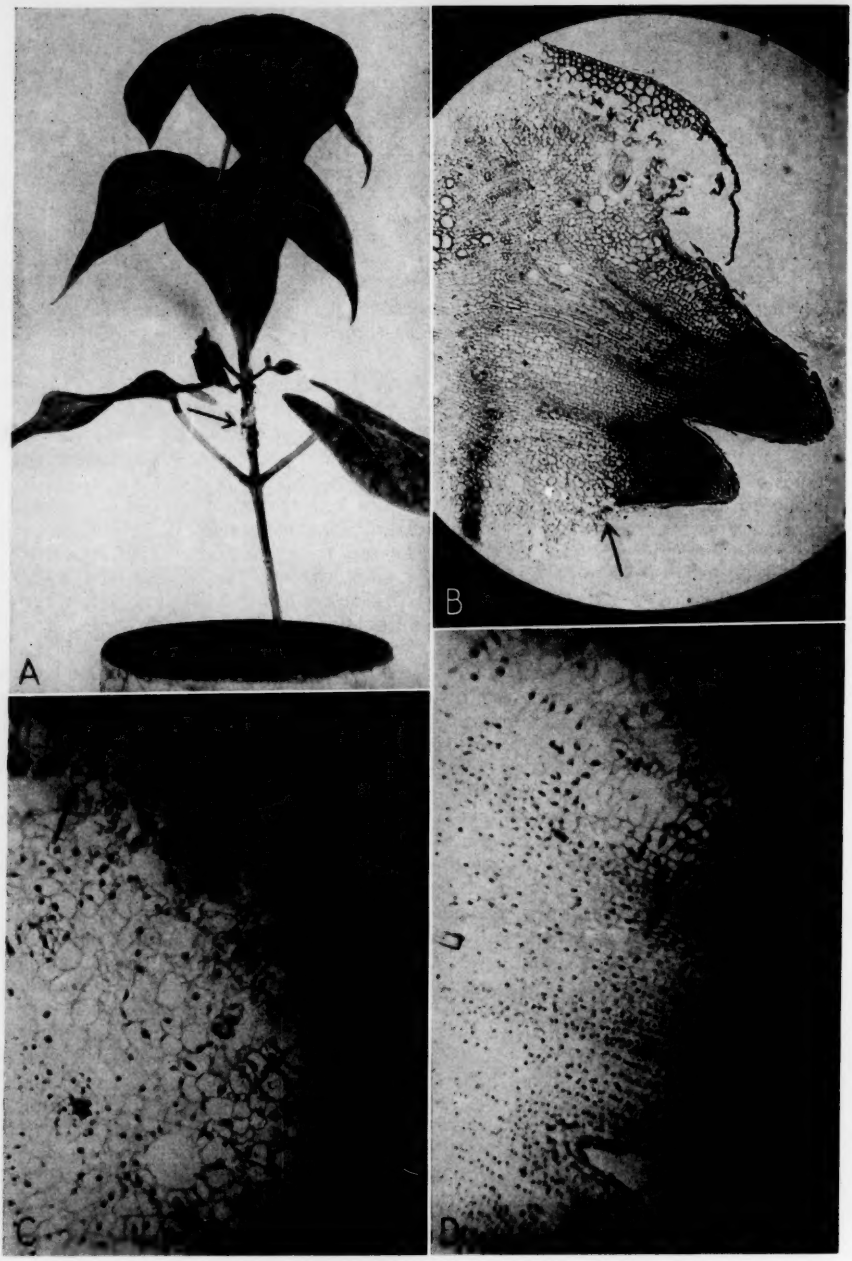
Cytological preparations from treated bean stems showed two conspicuous developments: (a) numerous root primordia were initiated; and (b) polyploidy was induced in some parenchymatous regions, both in the stem and in the root

*The writer wishes to express his appreciation of the assistance of Dr. H. DuBuy and Dr. Mark Woods, of the University of Maryland, who furnished the material on which these observasions were made.

†(A) Picric acid (sat.) 27 cc.
Formalin 25 cc.
Urea 1 gr.

(B) Picric acid (sat.) 57 cc.
Acetic acid 2.5 cc.
Chromic acid 1 gr.

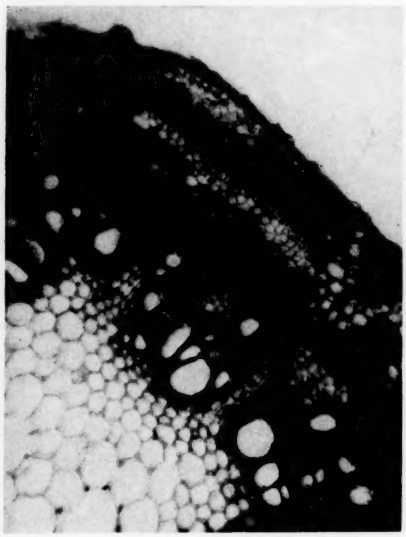
A and B solutions mixed in equal parts.



TUMOR-LIKE GROWTH AND POLYPLOID CELLS

Figure 11

A—The application of 0.25% naphthalene-acetic acid in a lanoline paste on the bean internode has produced tumorlike growth, 10 days old (about ½ normal size). *B*—Transverse section of tumorlike region shows general view of root generation and enlargement of cells in the cortical region as well as cells in the region of elongation in the root primordia. Magnification 35×. *C*—A portion of the cortical region shown in Figure 11*B*, where the enlargement of the cells with enlarged nuclei is apparent. The enlarged cells are easily ruptured from the pressure of the growing roots. Magnification 100×. *D*—Enlarged view of the elongation region in the primordial roots shown in Figure 11*B*, where linear arrangement of some enlarged cells containing large nuclei signifies that internally polyploidized cells are capable of self perpetuation and will build up polyploid tissues. Magnification 100×.



CONTROL SECTION
Figure 12

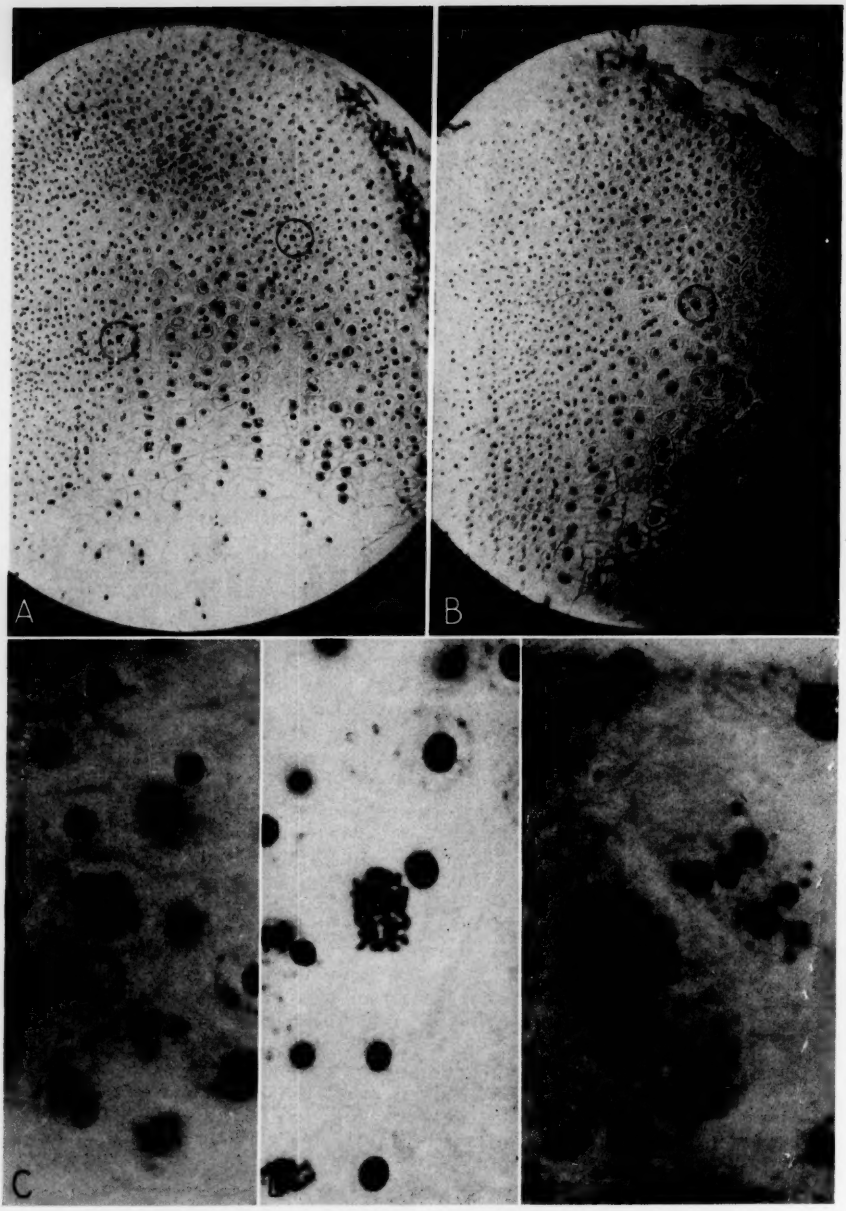
This is a transverse freehand section from an untreated bean stem, comparable to the one shown in Figure 11*A*. It was stained with aceto-carmine. Magnification 100×.

primordia. In addition to root primordia development, meristematic activity was initiated in differentiated parenchymatous tissues where normally such activity would not be present (Figure 12). Polyploidy was prevalent in the following parenchymatous regions: cortex (Figure 11, *B* and *C*), endodermal region which apparently is proliferated according to Kraus et al.,[6] phloem, medulary rays and pith of the stem; cortex and endodermal region (Figure 11, *B* and *D*) of the root primordia; in the root-cap cells of some root primordia; and rarely in the central region, immediately back of the growing point. No polyploid cells were observed in the cambial region of the stem and the procambial region of the root primordia. In the highly meristematic growing points of many root primordia polyploidy was usually absent, but in a few instances it was observed there also. Such polyploidy might be associated with retarded growth. The writer could not determine with accuracy whether or not polyploidy had occurred in the pericycle.

Chromosome plates of 4*x* (Figure 13, *A* and *D*), 8*x* (Figure 13, *B* and *E*), and 16*x* were found. For contrast a 2*x* plate is shown in Figure 13, *A* and *C*. Chromosome plates at smaller magnification are indicated by circles. The plate with 16*x* chromosomes is not shown because it was cut in two in serial sectioning and because the plate was in an inverted position, not suitable for a photomicrographic illustration. The chromosome numbers here given are estimated and were not actually counted, since accurate counts of these often were not possible. The polyploidy in premitotic nuclei (resting nuclei) in all parenchymatous cells in this material was recognized from the fact that there was a definite similarity in size of those nuclei in the proximity of different series of chromosome plates shown in Figure 13.

In the chromosome plate shown in Figure 14, direct evidence was found of intranuclear chromosome doubling as reported by Berger[2] and Levan.[7] The bean has 11 pairs of chromosomes; during mitosis, as in other plants, its chromosomes are longer and more slender (Figure 13, *C-E*). In Figure 14 the chromosomal bodies are broadly rectangular, numbering 44, appearing to be a "tetraploid" number. However, when they were carefully studied with the aid of an oil-immersion lens, each of the 44 bodies was found to be composed of 2 chromosomes closely paired lengthwise. Therefore the chromosome number in this plate is not 44 but 88, an octoploid number as shown in Figure 13 *E*. It may be further noted that there was a tendency for these bodies to orient in pairs, secondarily.

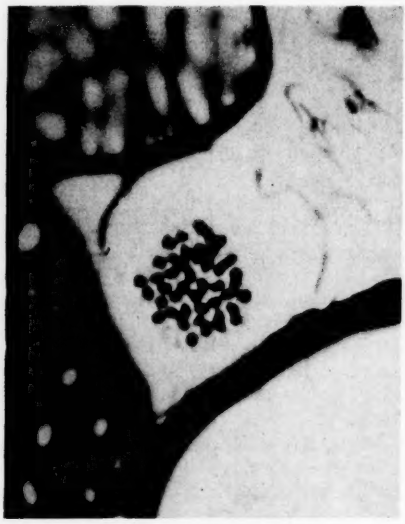
The above behaviors are interpreted by the writer as follows: Normally somatic chromosomes are two-parted, or each chromosome is composed of two closely associated chromatids that are ordinarily visible. With the chemical effect each chromatid becomes split in two; thus chromosomes become four-parted. Following this split, chromatid pairs open up distally into four arms but



NUCLEI SHOWING VARIOUS POLYPLOID COMPLEXES

Figure 13

Mitotic plates illustrated in this figure were from tangentially cut sections. *A*—The circle on the right encloses a 2*x* chromosome plate; that on the left encloses a 4*x* plate. Magnification × 130. *B*—The circle encloses an 8*x* chromosome plate. Magnification × 130. These two figures were from the same material only three sections apart in the serially cut paraffin sections. *C*—A 2*x* chromosome plate from the section shown in Figure 13A. Other cells in the neighborhood of this plate, judging from cell dimensions as well as from the uniformity of nucleolar size, are undoubtedly diploid. Magnification × 1500. *D*—A 4*x* chromosome plate; upper right cells are apparently tetraploid, while the cells on the lower left are diploid. Magnification × 1500. *E*—An 8*x* chromosome plate. Very large nucleoli indicate that the cells in the neighborhood of this plate are also octoploid. Magnification × 1500. Based on size relationship, indicated above (especially in Figure 13*A* and *B*), it seems apparent that polyploidy in the tumorlike growth on the bean stem may have reached to 16*x* and as high as 32*x* chromosome numbers.



DOUBLE CHROMOSOMES
Figure 14

This plate was obtained from a second bean plant treated as the first plant shown in Figure 11*A*. The material was sectioned transversely 20 days after treatment. The cell showing the chromosome plate was located between pith and stele of the stem. It shows 44 chromosomal bodies, each with two chromosomes intimately associated. The chromosome bodies show a certain amount of secondary pairing. These peculiarities suggest that this plate has resulted from two successive chromatid splittings during the nuclear stage. Magnification × 1500.

remain attached only at the polar (centromere) region. If mitosis followed after this split it would result in a chromosome plate that would contain 22 chromosomal bodies in bean material, similar in appearance to those of Figure 14, each being a pair of closely held chromosomes. However, intranuclear chromatid splitting may take place more than once. Following a second intranuclear split, chromosomes become eight-parted, but apparently only four chromatids or two sister chromosomes may be held together at a common polar region; thus the number of such chromosomal bodies, as shown in Figure 14, becomes 44, as appears in the plate. Chromosomal bodies of the same origin will tend to orient closely, as was pointed out above. Another plate of 88 chromosomal bodies, which was mentioned above, must have resulted through three splittings, thus increasing the number of chromosomes from 22, the 2*x* number, to 176, the 16*x* number. There are some nuclei (Figure 13, *A* and *B*) in which the chromosome number was probably increased to 352, the 32*x* number. The presence of mitotic phases with a high number of chromosomes, and the linear arrangement of large nucleated cells (Figure 11, *B* and *D*) are evidence that intranuclear increase of chromosomes will result in polyploid areas in the affected tissues.

The polyploidy induced in plants by colchicine results from the failure of chromosome separation at the mitotic stage[4]; whereas polyploidy resulting from applications of naphthalene-acetic acid, and perhaps with other similar chemicals, is attributed to an internal effect in the premitotic nuclei. At present it is not known whether such chemicals will induce polyploidy in as many plants as will colchicine. If it should prove to be as widely applicable as the colchicine method, the production of polyploidy by this technique ought to be the more efficient method, since in a meristematic region all or the bulk of the cells are at a premitotic stage, while the percentage of cells at metaphase is small.[3] The efficacy of such organic chemicals as polyploidizing agents will also depend upon whether or not all parenchymatous regions may be affected by the treatment. In our material, as well as in the material illustrated by Levan, the division region of the root tips and similarly meristematic tissues seem to remain normal, and only the parenchyma cells in differentiated regions are affected. This may prevent such chemical treatments from being totally effective in producing polyploid plants. This difficulty, however, may perhaps be overcome by devising adequate techniques to obtain totally polypolid shoots or roots.

The suggestion is offered that the tetraploidy in some leguminous plants associated with nodule formation described by Wipf and Cooper,[9] the polyploidy of

the shoots from normally developing callus of the tomato reported by Lindstrom and Koos,[8] and the similar phenomenon reported by Greenleaf[5] in *Nicotiana* following a chemical treatment may have been of the same nature as that here reported and may have resulted from intranuclear chromosome multiplication. In this connection, Wipf and Cooper's illustrations, Figures 8 and 9, are most revealing. The chromosome arrangement in their Figures is exactly as presented in Figure 14 of this text, although their material is better illustrated by camera-lucida drawings. These authors stated: "Binucleate cells (Figure 10) are occasionally present. . . . It may be that the disomatic cells [tetraploid] arise as the result of a fusion of the nuclei in such cells." They do not offer any explanation as to how chromosomes they have illustrated become so closely associated, even if tetraploidy could have arisen from a fusion between two nuclei. In our material such binucleate cells could not be detected. In the transverse sections there were numerous cells that suggested binucleate conditions, but in the longitudinal sections where boundaries of cells could easily be seen, such binucleate cells could not be found. Greenleaf also had suggested polyploidy in *Nicotiana* of binucleate origin.

The presence of large numbers of polyploid cells in the bean in regions treated with naphthalene-acetic acid strongly suggests that this growth substance was a factor in the polyploidizing of these parenchymatous cells. Possibly the accumulation of auxins or chemicals similar to growth-regulating substances may be a factor in the development of polyploidy in the tomato callus and legume nodules. The evidence presented by Levan and the present author shows conclusively that polyploidy in *Allium* and *Phaseolus* is of intranuclear origin, induced artificially, as seems also to be the case in *Nicotiana*; whereas polyploidy in tomato and legume nodules may be considered of natural occurrence.

The fact that intranuclear polyploidy occurs in the differentiated parenchymatous cells but not in the active meristematic cells might suggest that the chromosomes in the premitotic nuclei in the former are readily responsive and divide internally, while the rest of the cell constituents are not. This differential response to the chemical effect may explain the occurrence of polyploidy in the differentiated cells while the meristematic cells function normally.

The results from the standpoint of developing polyploid plants would depend on whether such polyploid tissues continue and proliferate and possibly differentiate as polyploid structures, whether such cells or tissues remained more or less isolated, without continued division, or whether they underwent disintegration and formed no new or additional significant structures.

It is suggested that when certain plants are treated with growth-regulating chemicals, polyploidy may be induced in some parts of the treated plants, resulting in a mixture of diploid and polyploid tissues. Various biological consequences of such a disturbance should not be overlooked.

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PARTIAL DOUBLING OF BOTH WINGS IN A RING-NECK PHEASANT*

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COMPLETE or partial reduplication of limbs is not uncommon among many groups of vertebrates. Polydactyly is quite frequently met with in many species as a mutant. In birds it may involve reversion to a primitive condition of the wings by reappearance of suppressed or vestigial digits, or it may be true polydactyly with rudiments of digits to the number of more than five. The commoner cases of supernumerary wings or legs in birds, however, seem to involve partial twinning of the principal axis of the embryo leading to very closely cojoined or Siamese twins, or to reduplication of the whole wing, sometimes including parts of the girdles. Such cases are probably due to division of the wing primordium in early embryonic life.

Twinning of the wing distal to the elbow is rare. It can hardly be attributed to mirror imaging of the limb as the result of injury to the primordium, especially if it occurs in both wings about equally. Such injury to both wing-rudiments in the same bird and to similar degrees is unlikely, because one wing is hidden from approach under the embryo as it lies in the amnion in the blastodisc and both rudiments are protected by albumen, membranes and shell. It is much more credible that such anomalies are genetic mutations of inherent origin rather than the results of simultaneous mechanical interference or other environmental agencies.

No description of such an anomaly for either pheasants or poultry has come to our notice. One is therefore given for the record. It is so rare in pheasants that neither Albert G. Csech of the State Game Warden Service nor any of the pheasant breeders who have seen it had ever seen such a case before. All these men have seen and handled thousands of pheasants raised for restocking hunting areas.

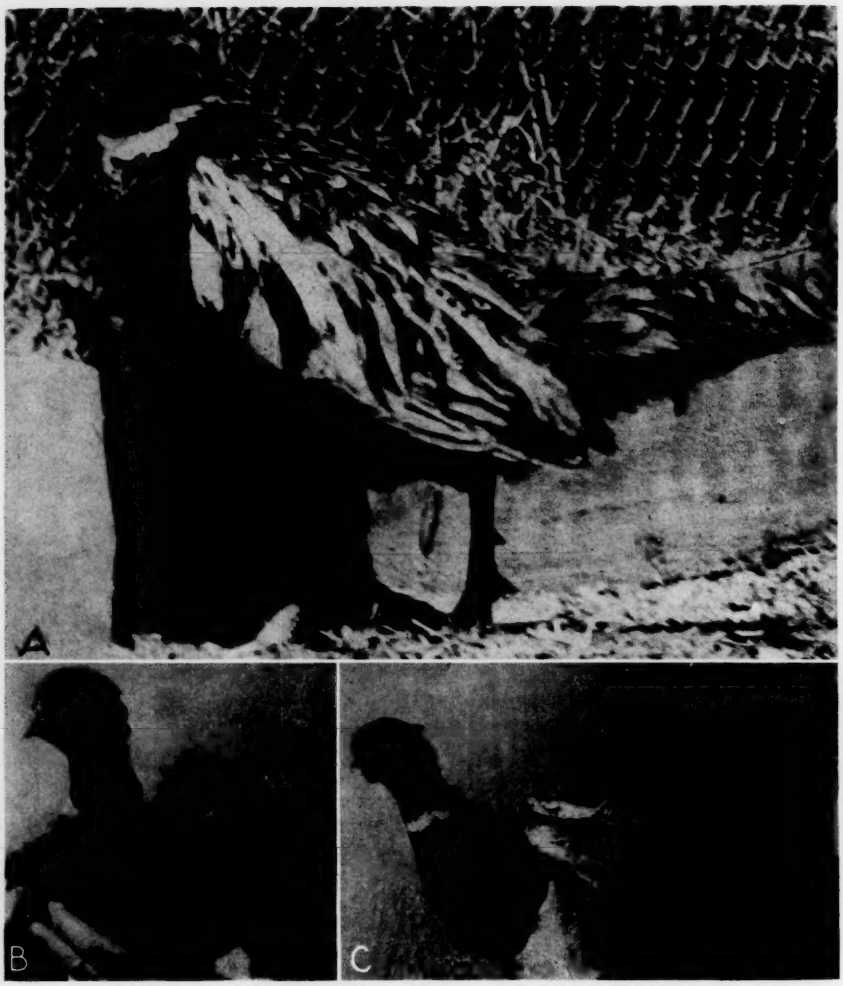
Description

A full-grown cock-pheasant of the Ring-neck variety, *Phasianus colchicus torquatus*, was secured through Albert G. Csech, of Shade Swamp Sanctuary, Farmington, Connecticut, on May 10, 1940, from R. N. Treat, Jr., a pheasant breeder of Woodmount, Milford County, Connecticut, who had raised him from the egg during the previous summer. We are indebted to Dr. R. P. Hunter, Superintendent of Fisheries and Game, for permission to have this bird for study.

The bird was considered by the breeders to have double wings because a supernumerary wing appeared on each side above those which correspond to the normal pheasant wing. He was a nervous bird of the type much sought after by sportsmen and bred for by the Board of Fisheries and Game of this State. These supernumerary or secondary reduced wings resembled epaulettes attached to the shoulders (really above the wrists) of his normal or primary wings. The wrist, metacarpal and phalangeal elements, in normal form and relations, were present in the post-axial member of each wing-complex and there was in addition a preaxial rudimentary hand with one digit (Figures 15 and 16).

The fundamental or primary wings were feathered normally so far as could be determined from casual observation (Figure 16*A*). Alae spuriae were present and normal. Cranial to them and overlying them and each wrist was a tuft of large strong flight feathers resembling

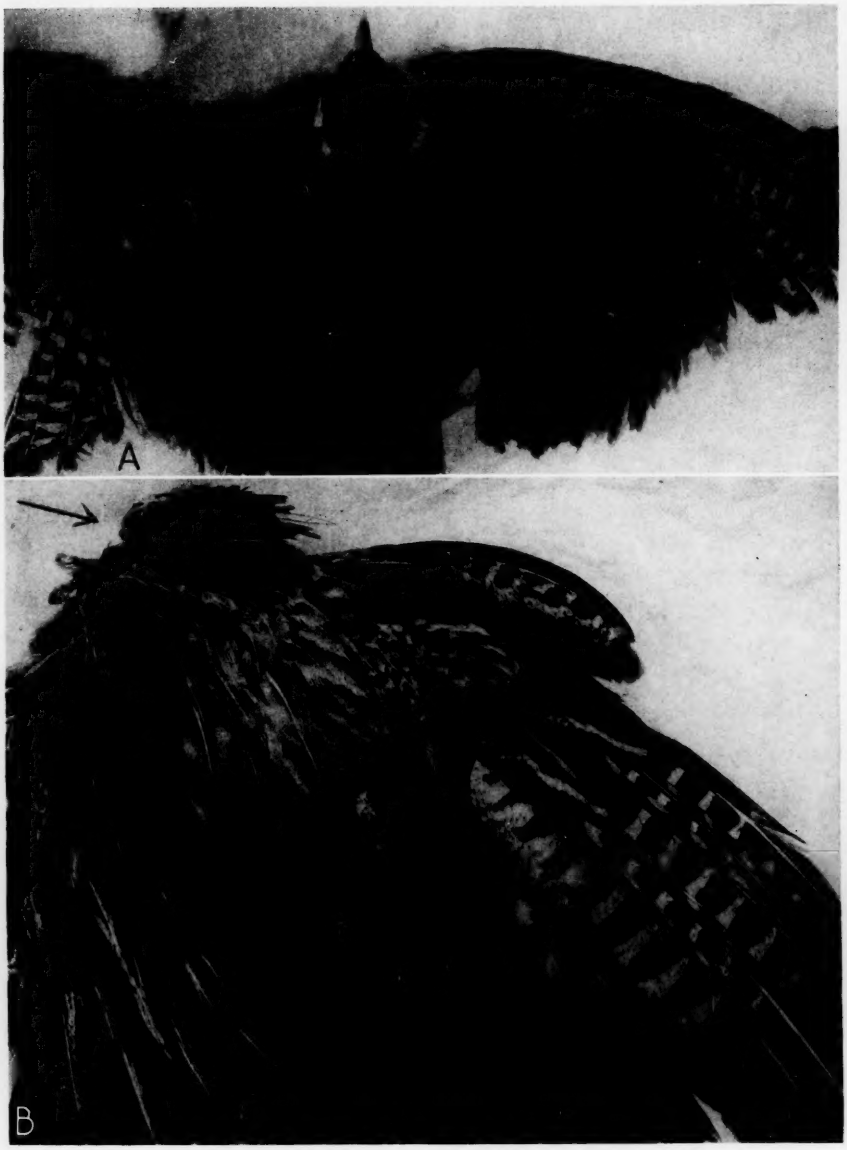
*Aided in part by a grant from the Penrose Fund of the American Philosophical Society, 1940.



APPEARANCE OF DOUBLE WINGS

Figure 15

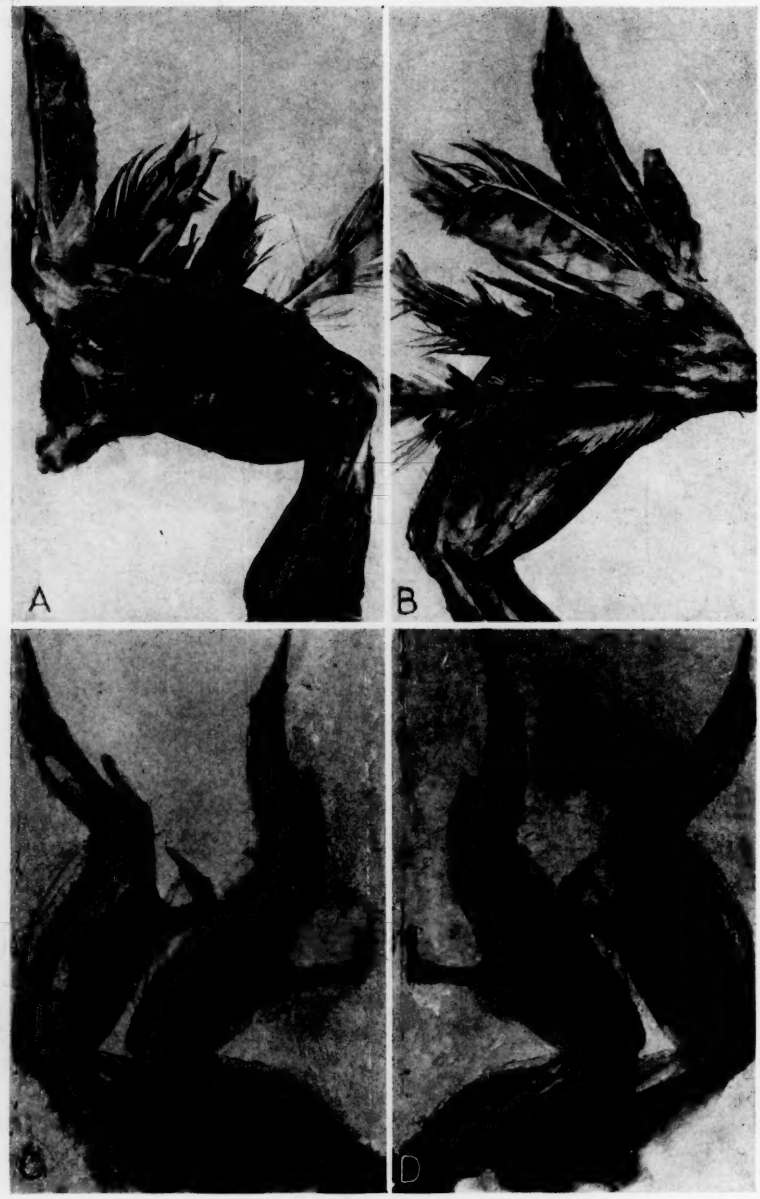
A—Side view of double-winged male Ring-neck Pheasant (*Phasianus colchicus torquatus*). *B*—Front view of double winged pheasant with accessory wings lifted up. *C*—Side view to show left accessory wing in relation to primary wing.



DETAILS OF DOUBLE WINGS

Figure 16

A—Dorsal view of double-winged pheasant with wings spread. Note shadow at the left of photograph which shows the angle of the accessory wing. *B*—Dorsal view of expanded right wing-complex showing *Ala spuria* and accessory wing tuft.



ANATOMICAL STRUCTURE

Figure 17

A—Ventral view of left wing-complex with fundamental or primary wing skinned, accessory or secondary wing not skinned, showing size of its flight feathers. *E*—Dorsal view of left wing-complex to show direction and size of the feathers of the accessory wing. *C*—Dorsal view of one, ventral view of the other wing-complex after Potassium-hydroxide-alizarin-red technique followed by glycerine, to show osteology of each. *D*—Views of wing-complexes reversed to show the other views of the bones.

primaries and a few smaller feathers, mostly broken off at about half their length by getting in the way during flight and catching in the wire netting of the pens in which he was reared. These feathers were attached to a finger-like digit, with two or more bony phalanges, extending dorsally and caudally from a wrist-like joint distal to the preaxial limb of a forked radius, the other limb of which participated in forming the wrist of the primary wing of each side. This "accessory wing" extended forward, then dorsally and backward from the margin of the alar membrane or propatagium between the humerus and radius (Figures 17*C-D*). It was easily determined in the living bird that the basal segment of each accessory wing was attached rigidly to the radius of the primary wing, forming one limb of a Y-shaped bone, the other limb of which articulated with the carpus or wrist bones of the primary wing. The joint between the accessory radius and the two or more phalanges of the accessory hand was movable within narrow limits. It is improbable that it was under voluntary muscular control, for the bird was not seen to move this wing separately from the primary one (Figures 15*B*, 16, 17*C-D*, and the shadows in Figure 15*C*). This joint is interpreted as an accessory wrist.

The supernumerary wing rudiments did not interfere with flight in the open; but they caught in the wire netting of the pens when the bird flew against them and would catch in bushes and similar impediments in normal habitats. That the digit was not broken off by such accidents is evidence of the strength of the ligaments of the joints and their flexibility. One accessory wing had one or two feathers larger than those in the other (Figures 16*A*, 17*A-B*). Each of them projected at about two-thirds of the distance from elbow to wrist. Its feathers were borne along the margin of the digit in much the same manner as the primaries on the carpo-metacarpus and digits to the primary wing, but lay more nearly parallel to the bones or phalanges.

Dissection after skinning showed that some muscle slips extended into the accessory hand and digit along the accessory fore-arm or radius from those of the primary forearm. Slips from the extensor metacarpi-radialis longior and pronator brevis were two. Another took origin from the outer side of the radius, proximal to its bifurcation, with its tendon of insertion extending to or beyond the accessory wrist. This muscle was more fleshy and conspicuous in the right wing than in the left. Slips from other muscles of the forearm also may have extended into the accessory wings by their tendons of insertion. If so, they were indistinguishable from fascia. If there were muscles intrinsic to the digits of the accessory wings they were too small and thin to be distinguished in gross dissection. The feathers of the accessory wings did not seem to be movable voluntarily. It therefore appears probable that such muscles, if present, were non-functional and very rudimentary. Nerve-supply to the slips mentioned were not found (Figure 17).

Clearing by the potassium-hydroxide-alizarin-red S technique followed by glycerine brought out the osteology of the doubled wings and the findings given above were confirmed (Figures 17*C-D*).

The bird was kept and night-lighted in a basement room, to be sure his sex-glands would not regress from reduced daylight, until he was sacrificed for anatomical study on June 12. He was in full breeding feather and sexual potency at that time (Figures 15 and 16). He was reported to have been used as a breeding male during April and May and requests for data as to any chicks from him showing doubling of the wings brought the following statement from Mr. Treat: "The bird which had the double wings was in a large breeding pen with thirty other cock birds and three hundred hens. No offspring from the pen had doubled wings."

This makes it appear unlikely that this is a dominant character possessed by the bird in homozygous condition. While it also appears unlikely that he was heterozygous for it if it is a dominant character, there is the bare possibility that the

chicks or eggs possessing it failed to hatch. If it is recessive it should show up in the second generation providing the birds carrying it are used as breeders next spring. This will be checked next summer.

Summary

Anatomical characteristics of double wings in a mature Ring-neck cock pheasant are described and figured. Forking of the radius of both wings with one side of the Y completing the postaxial fundamental wing and the other projecting preaxially to serve as base for an accessory wing with one digit of two or more phalanges was the basis for the doubling. Muscle slips from the normal wing were extended into the accessory one and large feathers resembling primaries were borne along the margin of the accessory digit. The abnormality did not appear in the first generation of chicks from eggs sired by this bird used with twenty-nine other cocks in a breeding pen with 300 hen-pheasants.

✦

AN AGE OF SCIENCE?

THE services of science to society are, primarily increased knowledge and understanding. That such increased knowledge, understanding and control of the forces of nature are used, not by scientists, but by society, with increasing effectiveness in the continuous and recurrent drives to satisfy greed, lust, hate and vanity, will, in my judgment, ultimately prove to be due, not to the inherent nature of the scientific method or of knowledge in itself, but to the failure of man, so far, to be effectively influenced by science and the scientific method.

It is sometimes asserted that science is amoral if not immoral. The latter may be true, if it is immoral to challenge and destroy taboos and traditions based on ignorance and misunderstanding. But to call the impartial, industrious and earnest search for new knowledge amoral or immoral, conflicts with my conception of immorality. As I understand it, there is no conflict between the scientfic method and our sense of justice, though I admit that the latter stems from a much broader base than science.

The evident failure of modern science to measurably influence human drives and conduct, individually, nationally, internationally, are probably to be sought in several factors. One is the character of our prevailing education. Starting in the home and in the church, in the grade school and the high school, and extending into the college, our education is largely education by dictation. It is indoctrination rather than education by understanding the why and wherefore through experimentation and controlled observation. This applies to countries other than our own.

There are those in our own country who insist all along the line of education by more and more dictation and indoctrination. Merely the memory of and the ability to repeat a heterogeneous number of facts, or even coordinated facts discovered and interpreted by science, is not education in the method of science. We can teach a parrot to talk Latin and repeat a syllogism, but that Latin-speaking bird is still a parrot.

Considerable responsibility for the failure of science to essentially modify human conduct must be laid to the scientists themselves. Many of us are scientists only during our working hours, and fall into the common errors of the average man when we step outside our own specific field.

Another factor is the tremendous resistance of man to new ways of thinking and new ways of life. During the past million years that man has evolved under the influence of the non-scientific or raw environment, he has developed emotions and habits and drives that are not easily, speedily or permanently modified by the environments and techniques developed by man himself through science.

There is no use crying over this situation. It is one of the recognized scientific facts, and we must accordingly work toward the goal with longer vision and greater tolerance and patience. Science as an educational and social force is but of yesterday.

As I see it, ours is not an age of science. Men are still driven by greed rather than guided by reason based on our expanding knowledge. Science has greatly enlarged man's understanding, conquered many of his diseases, lengthened his life, multiplied his joys, decreased his fears, and added much to his physical comforts and powers. But man may and does use these and other achievements for a greater social injury, instead of for a further social advance.

Science is specifically human, in that it stems from the innate curiosity of all men, and the conspicuously plastic brains of the ablest, if not the noblest, of our fellows. If this be so, it follows that the scientific method and its products cannot be, in any fundamental and permanent sense, in conflict with human nature, though our present human society, a product of the past, dominated by greed, force and fear, may be and is in conflict with the scientific method.—A. J. CARLSON in *Sigma Xi Quarterly.*

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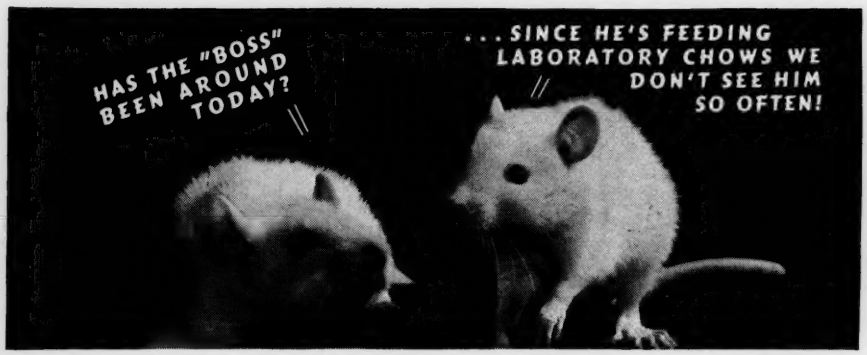

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